Predicting Load Carriage Injury Risk in Recreational Hikers

Maupin, Daniel; Mikhail, Monica; Schram, Ben; Orr, Rob Marc

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Predicting Load Carriage Performance in Recreational Hikers

Danny Maupin[1], Monica Mikhail[1], Robin Orr[1, 2], Ben Schram[1, 2]

[1]Faculty of Health Sciences and Medicine, Bond Institute of Health and Sport, Bond University, Robina, QLD: [2]Tactical Research Unit, Bond University, Australia.

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Background

- Load carriage is a vital task to all tactical personnel

- Particularly in military populations
  - Weight 45 kg[1]
  - Duration < 1 hour or > 3 days[2]

- Has major physiological effects
  - Increases in energy cost both static and dynamic[3]
  - Source of injury risk[4]

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Advanced Tactical Load Assessment System (ATLAS)

- Designed to assign an individual level of risk prior to load carriage task
- Utilizes Military Risk Management Framework
- Based on:
  - Estimated Workload as % of VO2 Max
- Further modified by:
  - Load as a % of Body Weight
  - Previous Injury
  - Previous Load Carriage Events

Risk level	Level descriptor	Endorsing authority
1 to 2	Extreme	Chief of Army
3 to 5	High	Formation Commanders
6 to 9	Substantial	Commanding Officer
10 to 16	Medium	Officer In Charge
17 to 25	Low	Section/Platoon Commander

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Estimating Workload

- Historically three equations
  - Giovoni and Goldman – original[6]
  - Soule and Goldman – expanded terrain[7]
  - Pandolf – expanded speeds[8]
- Estimate individual's aerobic capacity
  - 2.4 km Run
  - 20 m Progressive Shuttle Run Test
- Estimated workload is compared to maximum aerobic capacity

Level of risk	%VO2
1	100
5	82
9	66
10	62
13	50
15	42
16	38
17	34

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Equations

$$M = 1.5\ W + 2.0\ (W + L)(L/W)^2 + \eta(W + L)[1.5\ V^2 + 0.35\ VG]$$

M=metabolic cost (watts), W=subject's weight (kg), L=external load (kg), η=terrain type (graded 1.0 to 2.1), G=terrain grade (%), V=velocity (m/s)

Equations

$$+M = K\ L^2 V^2$$

M=metabolic cost (watts), K=the proportionality factor (hands =0.015 and feet = 0.064), L=external load (kg), V=velocity (m/s)

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Equations

$$M = 1.5\ W + 2.0\ (W + L)(L/W)^2 + \eta(W + L)[1.5\ V^2 + 0.35\ VG] + V^2(0.015L_H^2 + 0.064L_F^2)$$

M=metabolic cost (watts), W=subject's weight (kg), L=external load (kg), L_H = Load in hands, L_F = Load on feet, η=terrain type (graded 1.0 to 2.1), G=terrain grade (%), V=velocity (m/s)

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

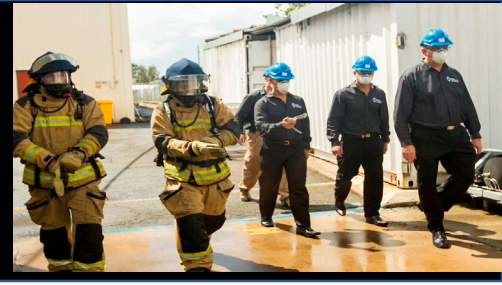
Estimating Workload

- Historically three equations
  - Giovoni and Goldman – original[6]
  - Soule and Goldman – expanded terrain[7]
  - Pandolf – expanded speeds[8]
  - **Equation promoted by Orr**
- Estimate individual's aerobic capacity
  - 2.4 km Run
  - 20 m Progressive Shuttle Run Test
- Estimated workload is compared to maximum aerobic capacity

Level of risk	%VO2
1	100
5	82
9	66
10	62
13	50
15	42
16	38
17	34

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE



Modifiers

- Percentage of Body Weight Load
- Previous Injury and Injury Site
- Previous Load Carriage Event

Previous load -carriage event	Change to Level of Risk Matrix
<14 days ago	+1
14–28 days	0
> 28 days	-1

Other site not identified above	-1	-0.5

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Methods

- Recreational hikers from Tasmania Walking Company
- Pre and Post hike questionnaire
- Self Reported
  - Metabolic Fitness
  - Weight
- Velocity collected by the Tasmania Walking Company
- Average incline determined using Google Map Software

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Results

- 31 Respondents
  - 7 Low Risk
  - 24 Medium

- 5 Total Injuries Reported

Risk Category	Level	Hikers	Injury
Medium	10	1	1
Medium	11	0	0
Medium	12	2	0
Medium	13	2	0
Medium	14	8	2
Medium	15	8	1
Medium	16	3	0
Low	17	2	0
Low	18	1	0
Low	19	4	0

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Discussion

- Limitations
  - VO2 Max based on self-reported data
  - Using averages does not account for variances along route
- Despite these limitations, this demonstrates ATLAS has capability to predict injury risk with limited sensitivity

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Conclusion

- Load carriage is a physically demanding task that can result in injury
- Being able to calculate risk associated with load carriage tasks beforehand can foster mitigation strategies
- ATLAS can be utilized with recreational hikers to predict task completion
  - Kokoda "death zone"
- ATLAS can also be used in tactical context to predict injury risk and mission success

vodafone AU 14:26 78%

Events

Overland Track
30 Sep 2018 - 6 Oct 2018

6 participants | Weight 12.5kg | Nights 5 | Days 6 | Distance 65km

Foster Lester Anderson Lars Brooks Steiner

Bay of Fires
3 Oct 2017 - 8 Oct 2017

6 participants | Weight 32kg | Nights 6 | Days 7 | Distance 55.12km

Lee Lester Anderson Lars Brooks Steiner

Wineglass Bay
1 Jan 2018 - 8 Jan 2018

13 participants | Weight 24kg | Nights 5 | Days 6 | Distance 35.7km

Lee Lester Anderson Lars Brooks Steiner Lester Anderson

vodafone AU 14:26 79%

Overland Track

Participants 6

Length	Days	Burden	Cumulative Gain
65km	6	12kg	+802m

Depart	Return
1pm Saturday 30 September 2018	10pm Sunday 6 October 2018

Participants

Jennifer T. Foster

BMI	Weight	Height	VO2 max
20.8	75.0kg	190cm	42.1

Age 45 | Sex Female | Injury

Risk: Medium 14

Jamie Lester

BMI	Weight	Height	VO2 max
20.2	84.1kg	178cm	55.3

Age 34 | Sex Male

Risk: Low 24

Tomakin J. Anderson

BMI	Weight	Height	VO2 max
35.5	94.1kg	188cm	32.56

Age | Sex

Risk: High 6

vodafone AU 14:25 79%

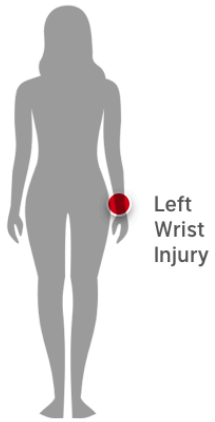
< Back

Jennifer T. Foster

Female 46

BMI	Weight	Height	VO2 max
20.8	75kg	190cm	45.1

Injuries (1)



Injury: Left Wrist

Occurred: 14 days ago

Treated? ✓

Pain 5/10

Fitness Test

2.4km Run Max Effort — endomondo

11:02 — 2 days ago ✓ VO2 max 45.1

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Questions?

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

Predicting Load Carriage Performance in Recreational Hikers

Danny Maupin[1], Monica Mikhail[1], Robin Orr[1, 2], Ben Schram[1, 2]

[1]Faculty of Health Sciences and Medicine, Bond Institute of Health and Sport, Bond University, Robina, QLD: [2]Tactical Research Unit, Bond University, Australia.

Contact: dmaupin@bond.edu.au

BOND UNIVERSITY
TACTICAL RESEARCH UNIT

TRANSFORM2019
PHYSIOTHERAPY CONFERENCE

References

1. Paulson LO: Light Infantry? A perspective on load carrying and the soldier, from past to present. Australian Army Journal 2006, III(2):81–88
2. Orr RM, Pope R, Coyle J, Johnston V: Occupational Loads Carried by Australian Soldiers on Military Operations. Journal of Health Safety and the Environment 2015, 31(1):451–467.
3. Beekley MD, Alt J, Buckley CM, Duffey M, Crowder TA: Effects of heavy load carriage during constant-speed, simulated, road marching. Mil Med 2007, 172(6):592–595.
4. Orr RM, Coyle J, Johnston V, Pope R: Self-reported load carriage injuries of military soldiers. International Journal of Injury Control and Safety Promotion 2016:1–9.
5. Givoni B, Goldman RF: Predicting metabolic energy cost. Journal of Applied Physiology 1971, 30(3):429–433
6. Soule RG, Goldman RF: Terrain coefficients for energy cost prediction. Journal of Applied Physiology 1972, 32(5):706–708
7. Pandolf KB, Givoni B, Goldman RF: Predicted energy expenditure with loads while standing or walking very slowly. Journal of Applied Physiology 1977, 43:577–581.